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FLOODS IN KANSAS CITY, MISSOURI AND KANSAS, SEPTEMBER 12-13, 19--ETC(U)

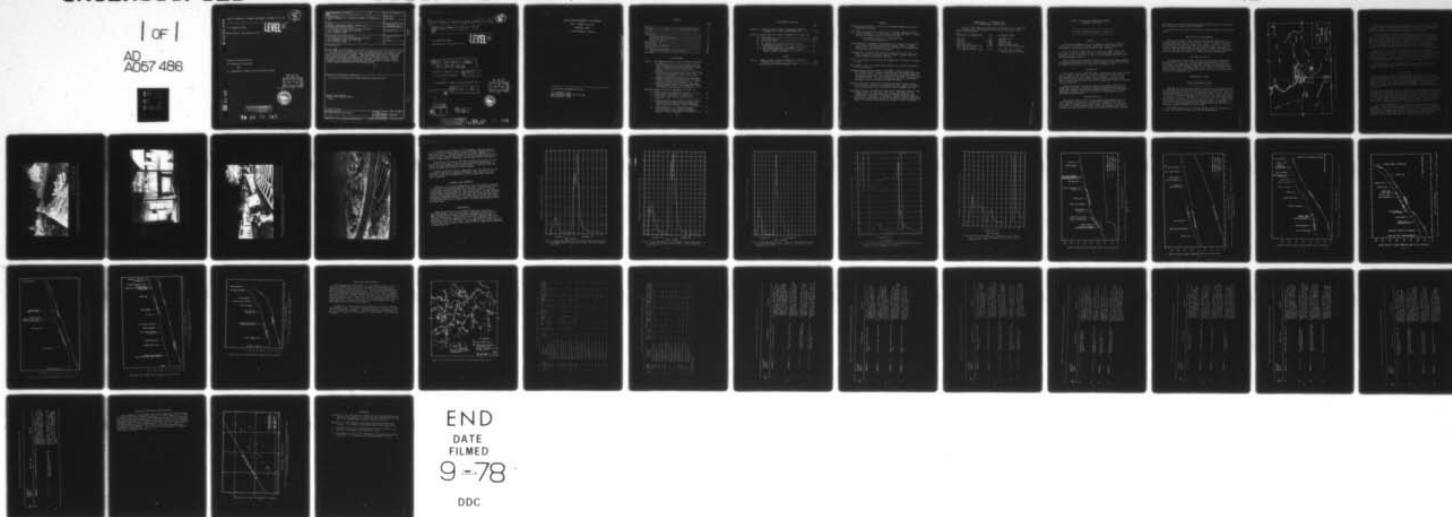
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FLOODS IN KANSAS CITY, MISSOURI AND KANSAS, SEPTEMBER 12-13, 1977

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U.S. GEOLOGICAL SURVEY

LEVEL II

Water-Resources Investigations 78-63

Prepared in cooperation with

U.S. Army Corps of Engineers

and

U.S. Department of Commerce, National Weather Service

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by Leland D. Hauth and William J. Carswell, Jr. 10

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GLOSSARY

Continuous-record station - A site on a stream where continuous records of discharge are obtained.

Cubic feet per second (ft^3/s) - The rate of discharge. One ft^3/s is the rate of discharge of a stream having a cross-sectional area of 1 square foot and an average velocity of 1 foot per second,

1 ft^3/s = 0.646 millions of U.S. gallons per day,
28.32 L/s or 0.022832 m^3/s .

Flood hydrograph - A graphical representation of a stream's fluctuation in flow (in cubic feet per second [ft^3/s]) during a flood, in chronological order. The graphical data are obtained by an instrument that continuously records these fluctuations.

Flood profile - A graph of the elevation of water surface of a river in a flood, plotted as an ordinate, against distance, measured along the stream channel, and plotted as abscissa.

Front - The interface or transition zone between two air-masses of different density.

Miscellaneous site - A site where data pertaining to a specific hydrologic event are obtained.

National Geodetic Vertical Datum of 1929 (NGVD) - Formerly called SEA LEVEL DATUM of 1929. A geodetic datum derived from a general adjustment of the first order level nets of both the United States and Canada. In the adjustment, sea levels from selected tide stations in both countries were held as fixed. The year indicates the time of the last general adjustment. Not to be confused with MEAN SEA LEVEL.

Rainfall mass curve - A graph of the accumulated rainfall depth, plotted as an ordinate, against time or duration of storm, plotted as abscissa. The curve represents total precipitation depth throughout the storm.

Recurrence interval - As applied to flood events, recurrence interval is the average interval of time within which a given flood peak will be exceeded once. Recurrence intervals are averages and do not imply regularity of occurrence. For example, a 100-year flood discharge will be exceeded on the average of once in 100 years; in terms of probability, there is a 1-percent chance that such a flood will occur in any year.

CONVERSION OF U.S. CUSTOMARY UNITS
TO SI (INTERNATIONAL SYSTEM OF UNITS)

For use of those readers who may prefer to use metric units rather than U.S. customary units, the conversion factors for the terms used in this report are listed below:

<u>Multiply U.S. customary units</u>	<u>By</u>	<u>To obtain SI Units</u>
inch (in.)	2.540	centimeter (cm)
foot (ft)	0.305	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi ²)	2.590	square kilometer (km ²)
cubic foot per second (ft ³ /s)	0.028	cubic meter per second (m ³ /s)
cubic foot per second per square mile (ft ³ /s)/mi ²	0.011	cubic meter per second per square kilometer (m ³ /s)/km ²

Floods in Kansas City, Missouri and Kansas,
September 12-13, 1977

By Leland D. Hauth and William J. Carswell, Jr.

ABSTRACT

The storm of September 12-13, 1977, produced as much as 16 inches of rainfall in the Kansas City, Missouri-Kansas area, left 25 persons dead, many homeless, and caused over 50 million dollars in damages.

Data from National Weather Service recording rain gages indicate the storm came in two bursts within 24 hours. Flood hydrographs developed from streamflow records in the area also reflect the two events, with the second yielding the greater runoff.

Peak discharges were determined during and after flood at gaging stations and selected miscellaneous locations. Peak discharges in areas of great rainfall depths were well over the criteria for the 100-year flood.

INTRODUCTION

Outstanding floods occurred on streams in the Kansas City, Missouri-Kansas area as a result of two separate rainfall events within 24 hours, each of which exceeded the 100-year 24-hour rainfall frequency. The first storm saturated the ground, which allowed a greater part of the second rainfall event to become overland runoff, thus causing streamflows in excess of 100-year recurrence intervals.

Twenty-five persons lost their lives and an estimated \$50 million in damages were reported. Although many homes and businesses suffered losses in the small stream basins, the major monetary damage occurred in the Brush Creek basin of Missouri and Kansas and within the lower Blue River basin downstream from 63rd Street.

Purpose and Scope

The purpose of this report is to document the outstanding floods for future hydraulic and hydrologic planning. Data related to such unusual flood events are essential to wise development within any river basin where the threat of flooding endangers public safety and property. This report presents storm and flood descriptions, peak stages and discharges, discharge

hydrographs, water-surface profiles of selected stream reaches and the approximate recurrence intervals of peak discharges.

Elevations in this report are referred to National Geodetic Vertical Datum (NGVD).

Cooperation and Acknowledgments

Rainfall data shown in this report were compiled and supplied by the National Weather Service, Kansas City, Mo. The National Weather Service also contributed the text section, "Description of Storm." Elevations for water-surface profiles of Brush Creek, Rock Creek (Kansas), Blue River, and Little Blue River were provided by the U.S. Army Corps of Engineers, Kansas City District. The Corps also provided personnel for the field crews. Photographs were taken by Frederick Solberg, Jr., "Kansas City Star" photographer.

Description of Area

The area covered by this report includes the Kansas City metropolitan area and extends 15 mi east. The area comprises approximately 1,000 mi². See figure 1. The three major streams where flooding occurred (Blue River, Little Blue River, and Sni-A-Bar Creek, fig. 15) flow into the Missouri River within a 40-mi reach. Streamflows shown in this report reflect runoff from both rural and urban areas. The western half of the area is urbanized and the eastern half is primarily rural.

DESCRIPTION OF STORM

By National Weather Service

September 12, 1977, was very unusual in Kansas City, Mo., because on that day there were two separate 6-hour rain events, each of which had a recurrence interval equivalent to a once-in-a-100-year event, according to the values in Weather Bureau Technical Paper No. 40 (Hershfield, 1961). That is, the average interval of time that the magnitude and duration of either storm event would be exceeded is 100 years. Although it is not rare in the Great Plains in the warm season for heavy rain to occur on successive nights, it is extremely rare to have both events maximize at exactly the same location, as happened at Kansas City. There was sunshine in the afternoon between the two events, and there were notable differences in their causes.

Both events occurred in air that was unstable, and with a high moisture content, thus conducive to heavy rain from the thunderstorms.

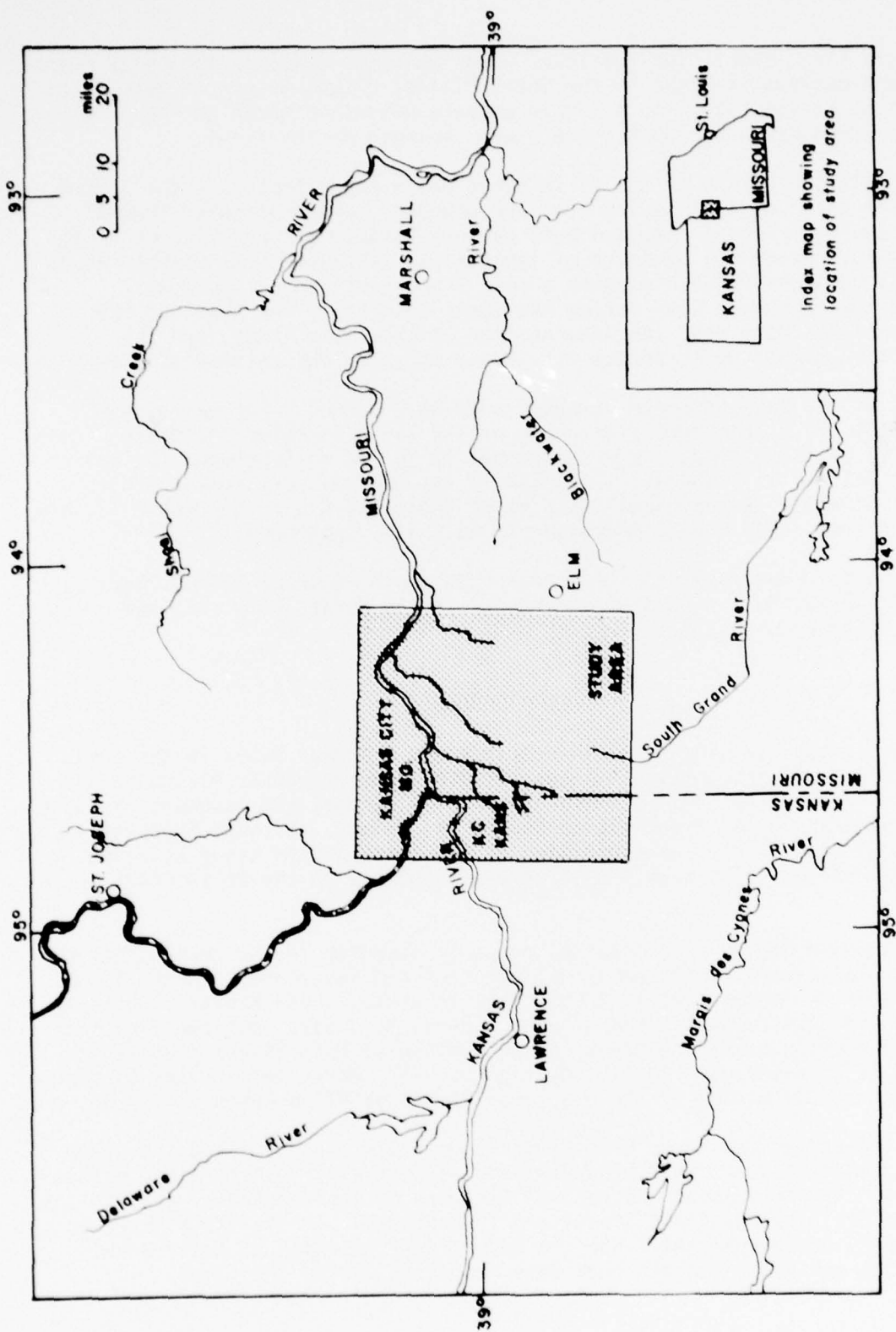


Figure 1.--Location of area of flooding in Missouri and Kansas.

In the first event, the low-level winds which so characteristically reach a prominent maximum at night in the Great Plains, flowed up over a warm front southwest of Kansas City, and the rain amounts maximized north of the front where the strongest winds during the night impinged on the front.

The rain-cooled air of the first event was a major factor in the second event later that day because its southern boundary, which extended from St. Louis to south of Kansas City and into eastern Kansas, either reinforced the warm front or became the boundary of importance. Thunderstorms started about where this boundary interacted with a cold front over Kansas which was advancing toward Kansas City during the sunny interval. The heaviest rainfall intensities were near the intersection of these two lines, and the precipitation maximized at Kansas City about the time the intersection arrived.

Most of the rain occurred in about a 25-hour period. For example, at Independence, Mo., recorder, 3 mi north of the 16-inch center indicated a total depth of 11.03 inches from 1 a.m. September 12 to 2 a.m. September 13, out of a storm total of 11.11 inches. The rain in the metropolitan Kansas Cities occurred primarily in two bursts, the first from 1 to 6 a.m. September 12, and the second from about 8 p.m. September 12 to 2 a.m. September 13.

The band of heavy rainfall extended from south of Grand Island, Nebr., to near Columbia, Mo., with maximum amounts in the Kansas City area and eastward to near Odessa, Mo.

FLOOD DAMAGE

Water damage was widespread in nearly every drainage basin in the area. Because of the high intensity of the storm, even some residents living on the slopes were not spared. Hillside runoff flooded garages and basements in some areas located above the flood plains during the deluge. Mission Shopping Center in Mission, Kans., was inundated by floodwaters from steep hillside slopes and overbank flow from Rock Creek, a tributary in the Brush Creek drainage basin.

The greatest damage to commercial property occurred in the Brush Creek basin and lower Blue River. Most commercial business and development in the flood-affected area is centered along Brush Creek in Missouri and Kansas. Shops and stores in the Country Club Plaza of Kansas City, Mo., just upstream from the U.S. Geological Survey Brush Creek gaging-station at Main Street received as much as 6 ft of water as evidenced by figures 2-5. Marks left by the flood can be seen in the window of the U.S. Post Office at Plaza Center (fig. 3).

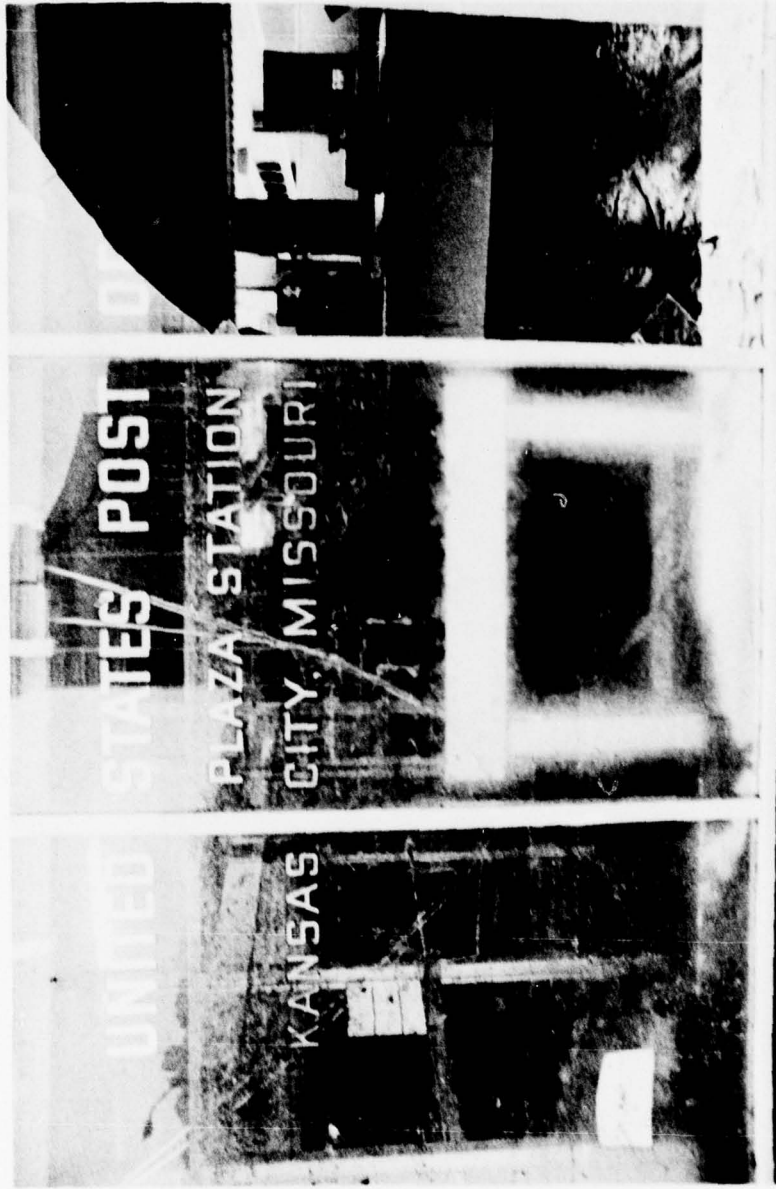
The industrialized lower Blue River flood plain also received its share of damage. Railroad tracks were undermined as much as 3 to 4 ft along bridge approaches. Figure 5 shows the general flooding in the industrial area in the Blue River basin between 23rd Street and Truman Road. In the Brush Creek basin, many shoppers had parked their cars in underground sections of multi-level parking lots and along streets that were inundated during the flood.



Courtesy of Kansas City Star,
Frederick Solbert, Jr., photographer

Figure 2.--View of Brush Creek after flood crest, looking east along Ward Parkway,
at Wornall Road at Country Club Plaza, Kansas City, Missouri.

Flood of
9-12-77,
high-water
mark.



Courtesy of Kansas City Star,
Frederick Seiberg, Jr., photographer

Figure 3.--United States Post Office, after Brush Creek flood crest, on Ward
Parkway at Country Club Plaza, Kansas City, Missouri.



Courtesy of Kansas City Star,
Frederick Solberg, Jr., photographer

Figure 4.--View of 600 block of West 48th Street, after Brush Creek flood crest,
at Country Club Plaza, Kansas City, Missouri.



Figure 5.--Areal view after flood crest, looking west along Blue River between 23rd Street and Truman Road at Kansas City, Missouri. (U.S. Corps of Engineers.)

A 10-county area was affected by the floodwater. Disaster relief to public facilities from the Federal Disaster Assistance Administration was 5.8 million dollars. Reported damages to the business community in commercial areas reached nearly 43 million dollars and grants from the Small Business Administration to individual families about 6.8 million dollars.

At the time of the flood, 1,539 flood-insurance policies were in force. As a result of the flood, 2.6 million dollars has been awarded by the Federal Insurance Administration to policy holders. Since the flood, 650 persons have made application for flood insurance.

Residents along Rock Creek in Independence, Mo., felt the brunt of the flood when 11 houses were completely destroyed. Homes were left in the middle of streets after floodwaters at ceiling levels floated them from their foundations.

RECORDED FLOOD HYDROGRAPHS

Figures 6 to 10 are flood hydrographs for the storm period at selected U.S. Geological Survey gaging-stations in the area. A rainfall mass curve is also shown for Round Grove Creek (fig. 9) where rainfall is recorded simultaneously with river stage in a dual gaging system. The gage structures on Rock Creek at Independence, Mo., and Brush Creek at Main Street at Kansas City, Mo., were damaged during the flood peak and parts of the flood hydrographs were computed on the basis of high-water marks, earlier flow records, and the stage record prior to gage failure. Estimated hydrographs are shown as dashed lines.

FLOOD PROFILES

Water-surface profiles of the flood on Blue River, Brush Creek, Rock Creek (Kansas), and Little Blue River are shown in figures 11 to 14. Where information is available, elevation of bridge floors is shown to indicate road overflow. The profile of the flood of September 1961 on the Blue River is shown for comparison (fig. 11). The effect of inflow from Brush Creek at mile 11.8 is evident. Flood boundaries along streams discussed in this report are available at the office of the U.S. Army Corps of Engineers, in Kansas City, Mo.

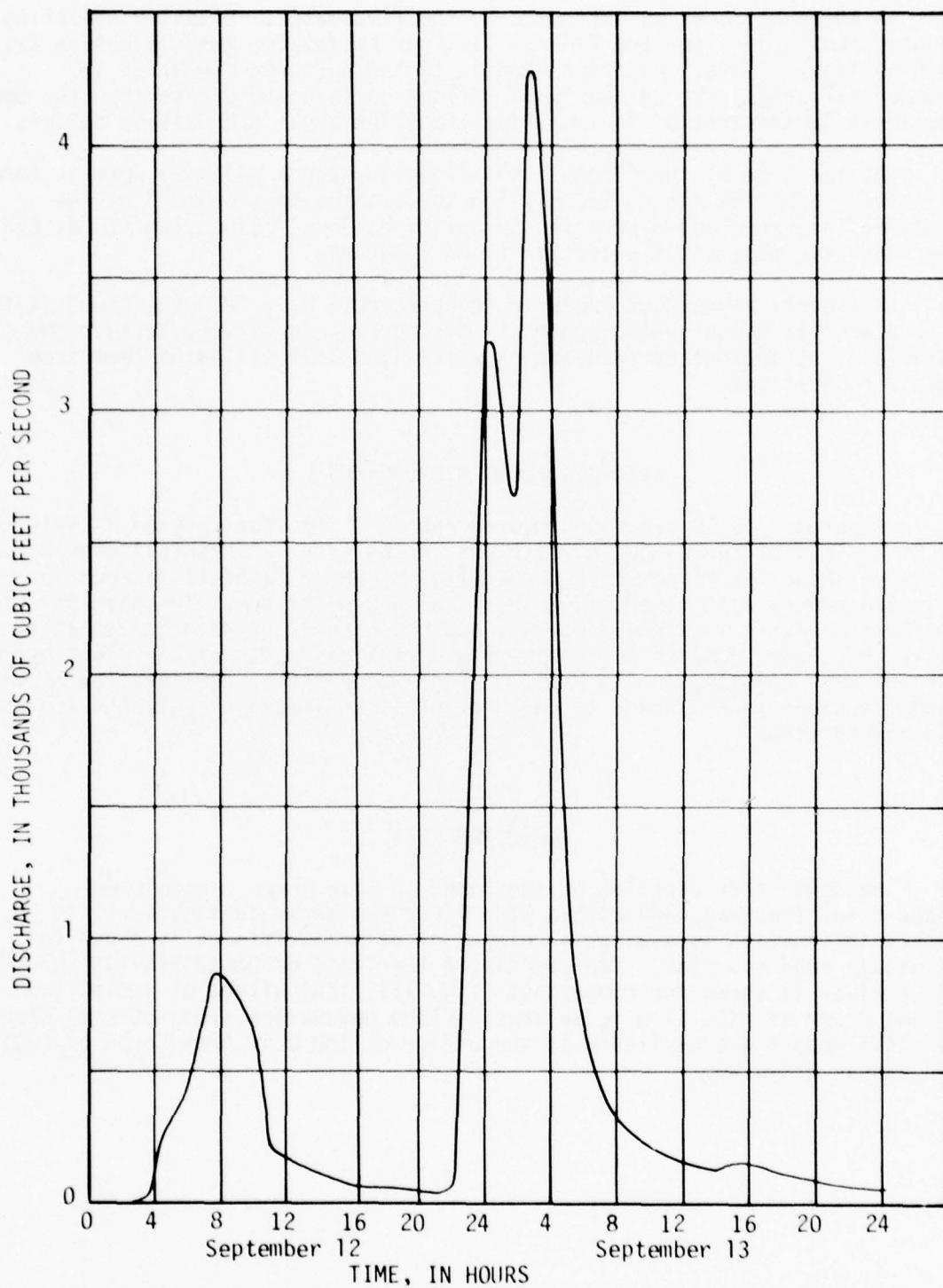


Figure 6.--Flood hydrograph at U.S. Geological Survey gaging-station, on Tomahawk Creek at Overland Park, Kansas, flood of September 12-13, 1977.

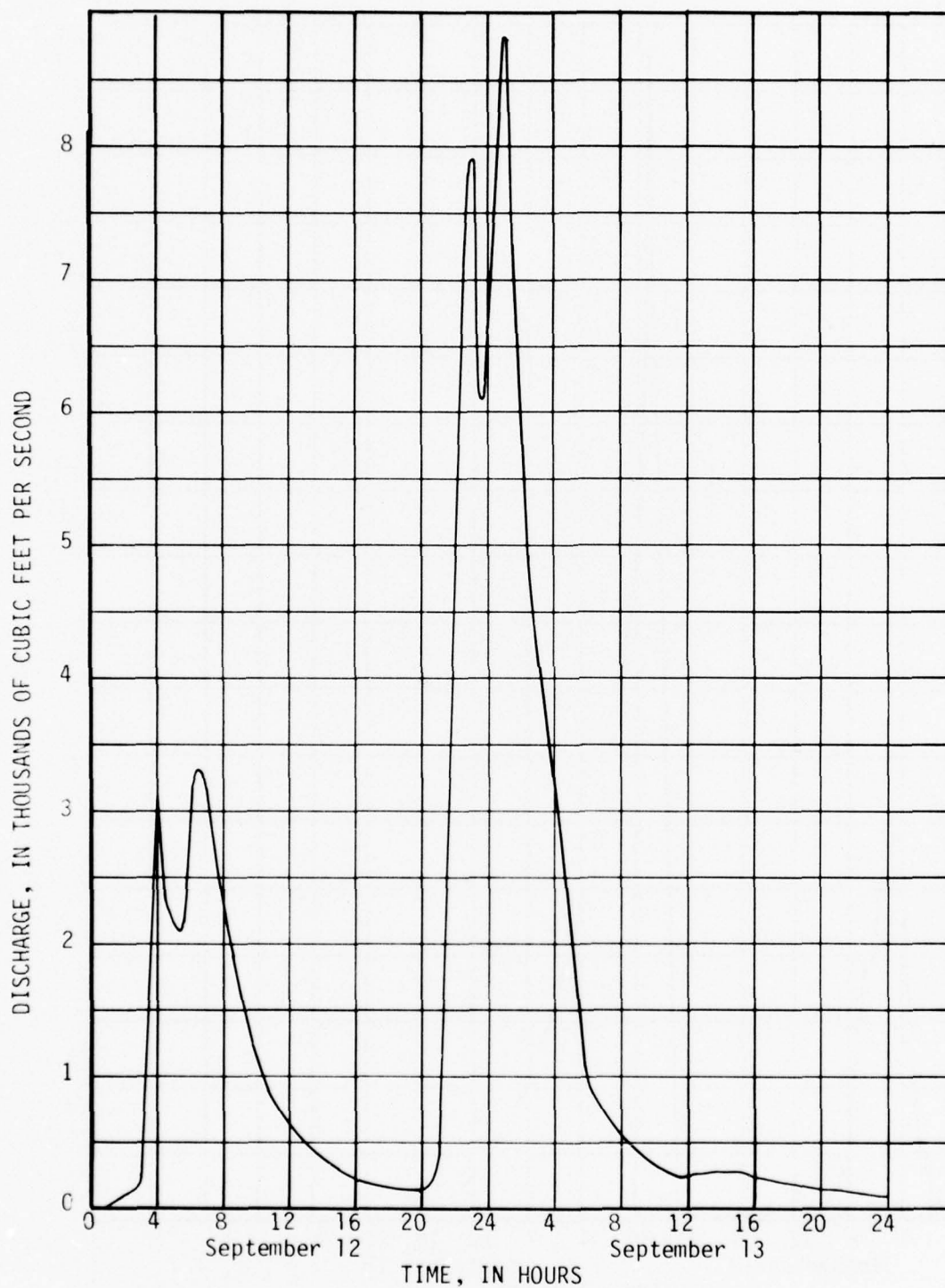
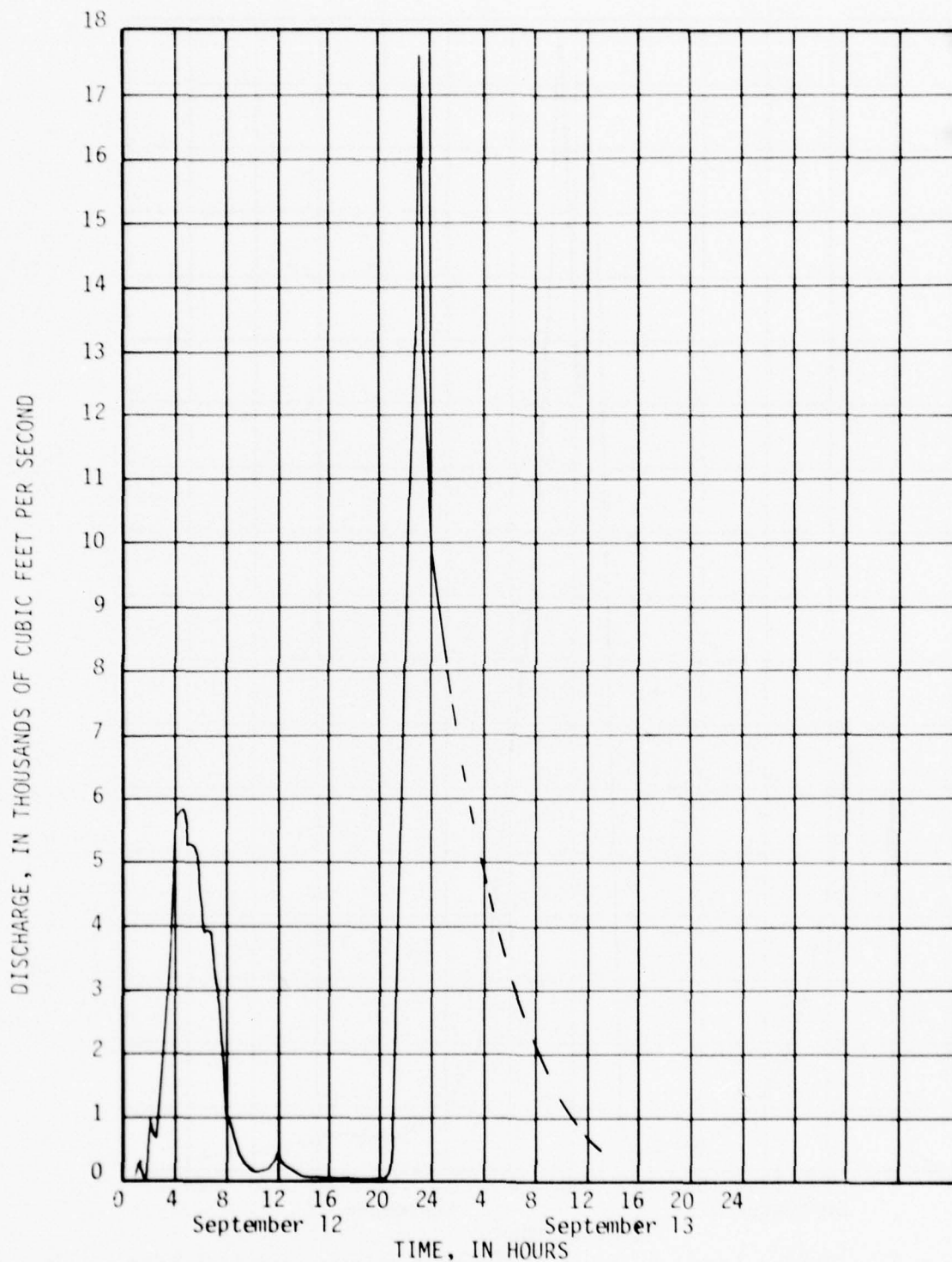


Figure 7.--Flood hydrograph at U.S. Geological Survey gaging-station, on Indian Creek at Overland Park, Kansas, flood of September 12-13, 1977.



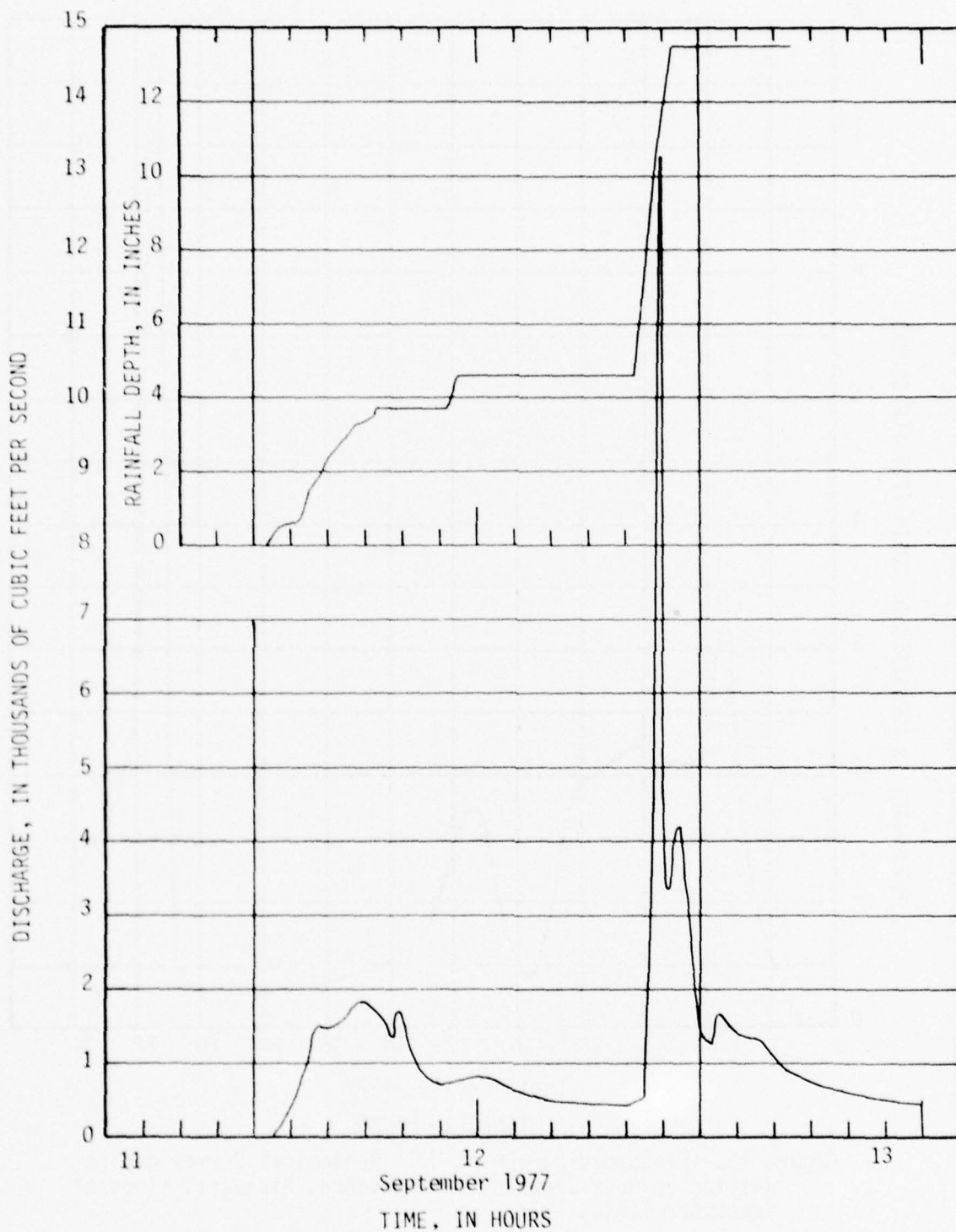


Figure 9.--Flood hydrograph and mass curve of rainfall at U.S. Geological Survey gaging-station on Round Grove Creek at Raytown, Missouri, flood of September 12-13, 1977.

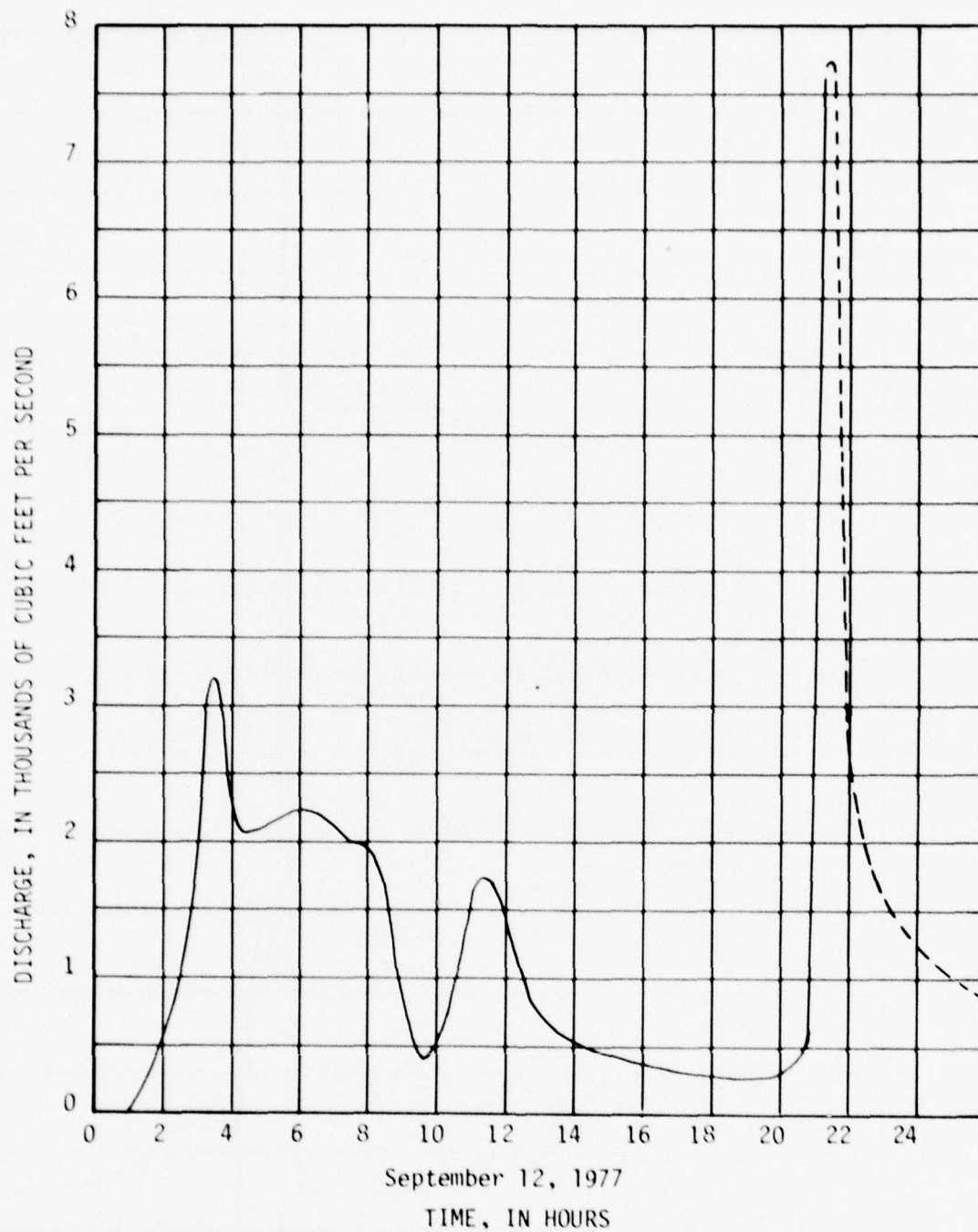


Figure 10.--Flood hydrograph at U.S. Geological Survey gaging station on Rock Creek at Independence, Missouri, flood of September 12-13, 1977.

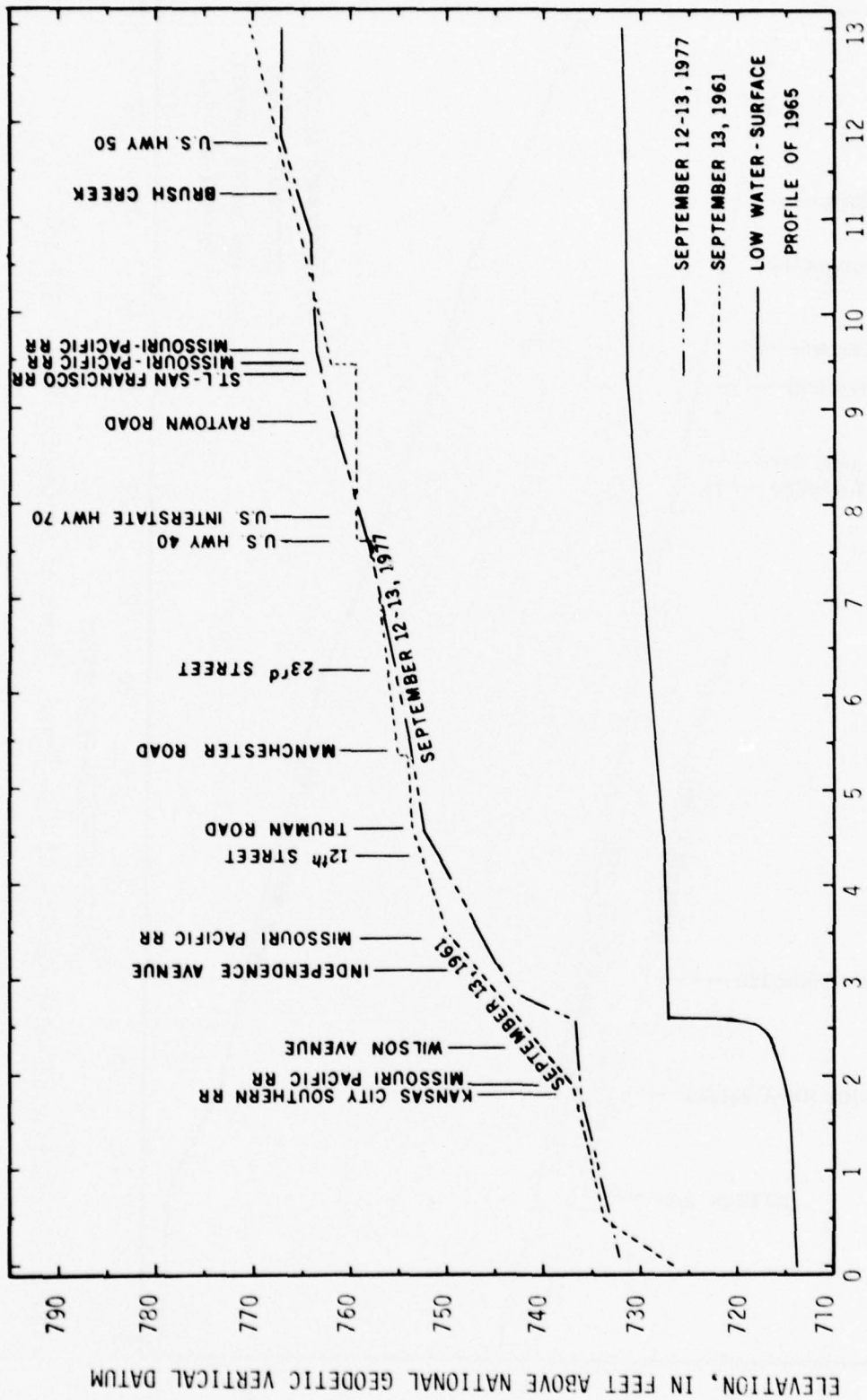


Figure 11.--Profile of water surface of Blue River, floods of September 12-13, 1977 and September 1961.

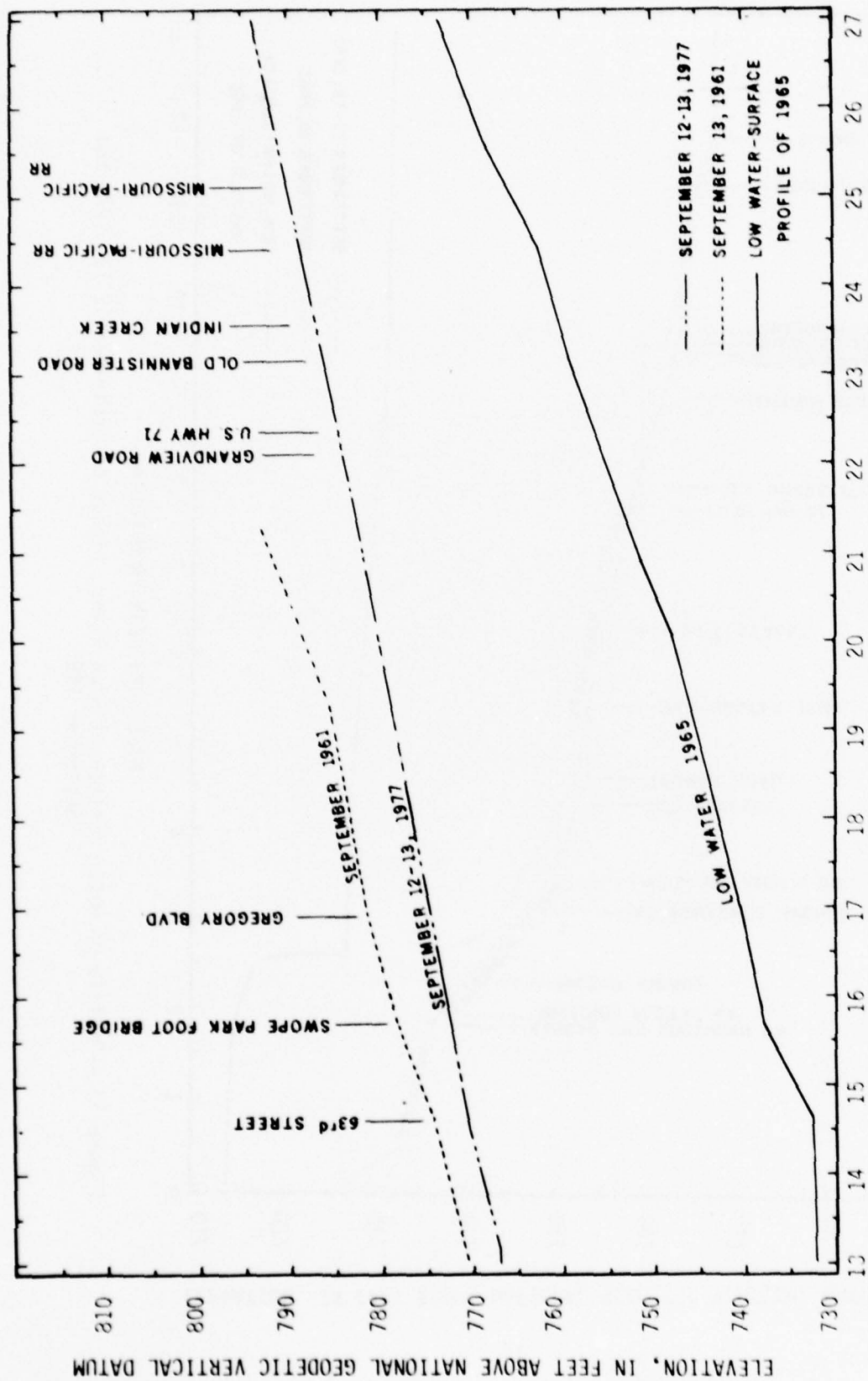


Figure 11.--Profile of water surface of Blue River, floods of September 12-13, 1977 and
 September 1961--continued

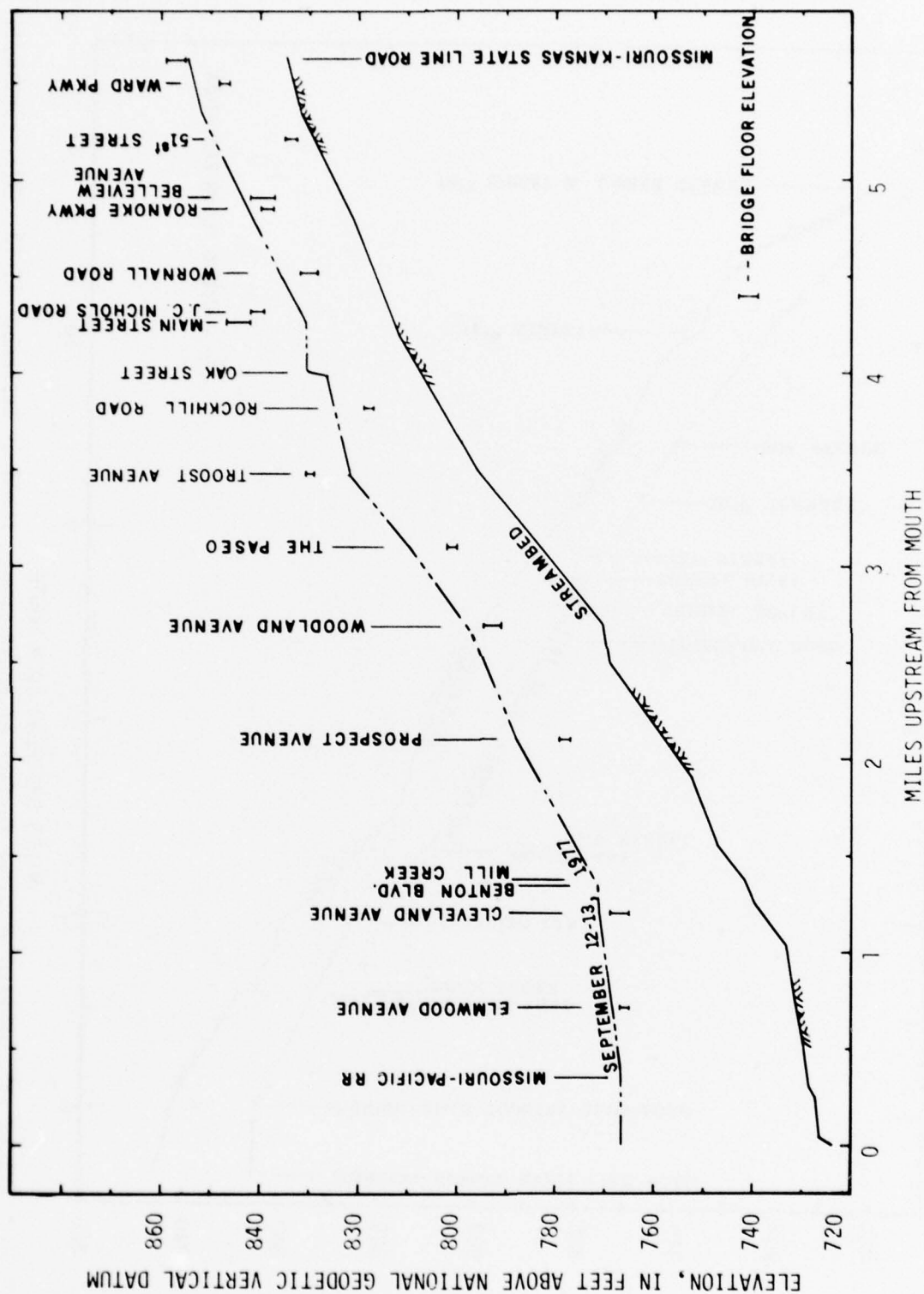


Figure 12.--Profile of water surface of Brush Creek, flood of September 12-13, 1977.

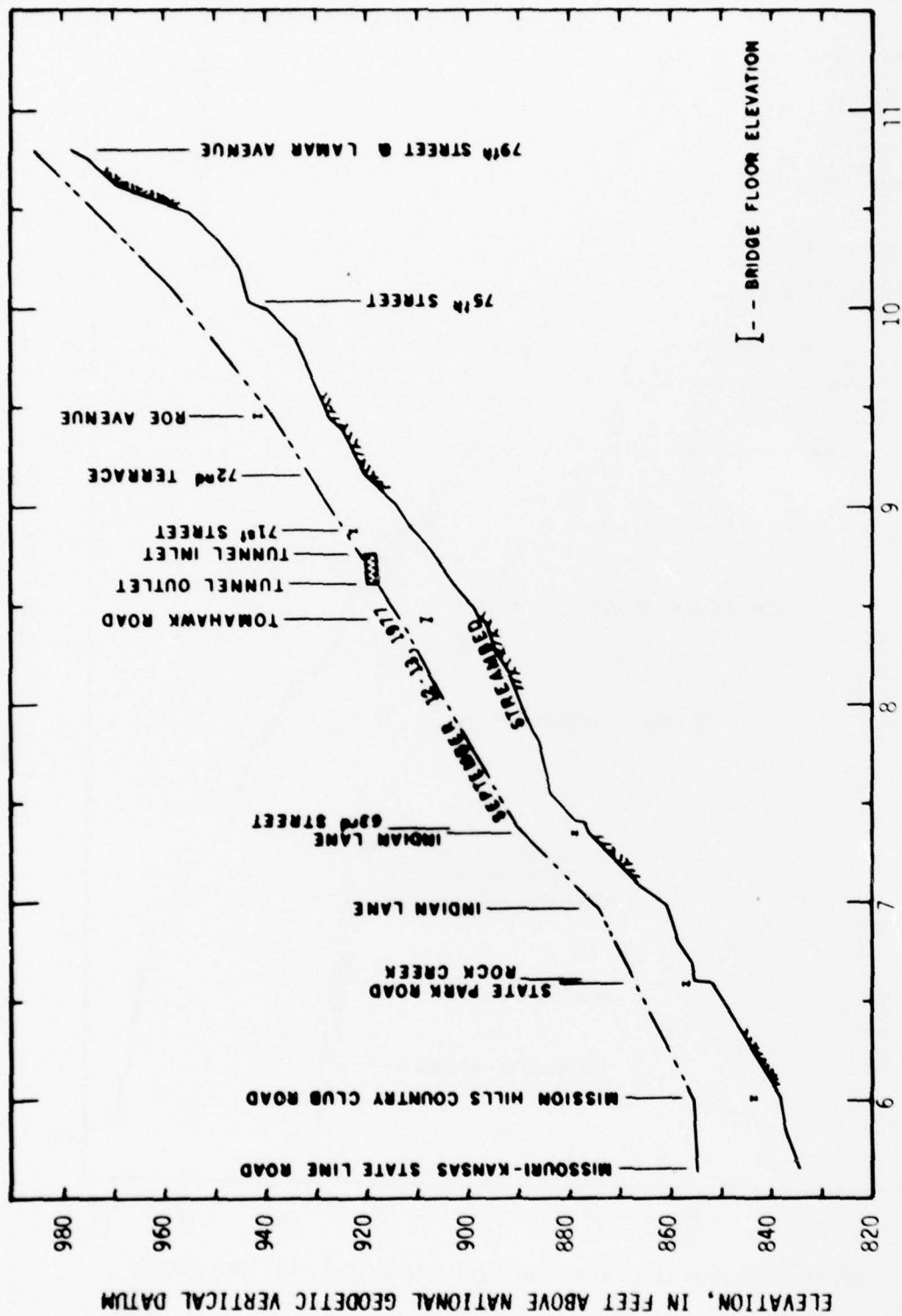


Figure 12.--Profile of water surface of Brush Creek, flood of September 12-13, 1977--continued

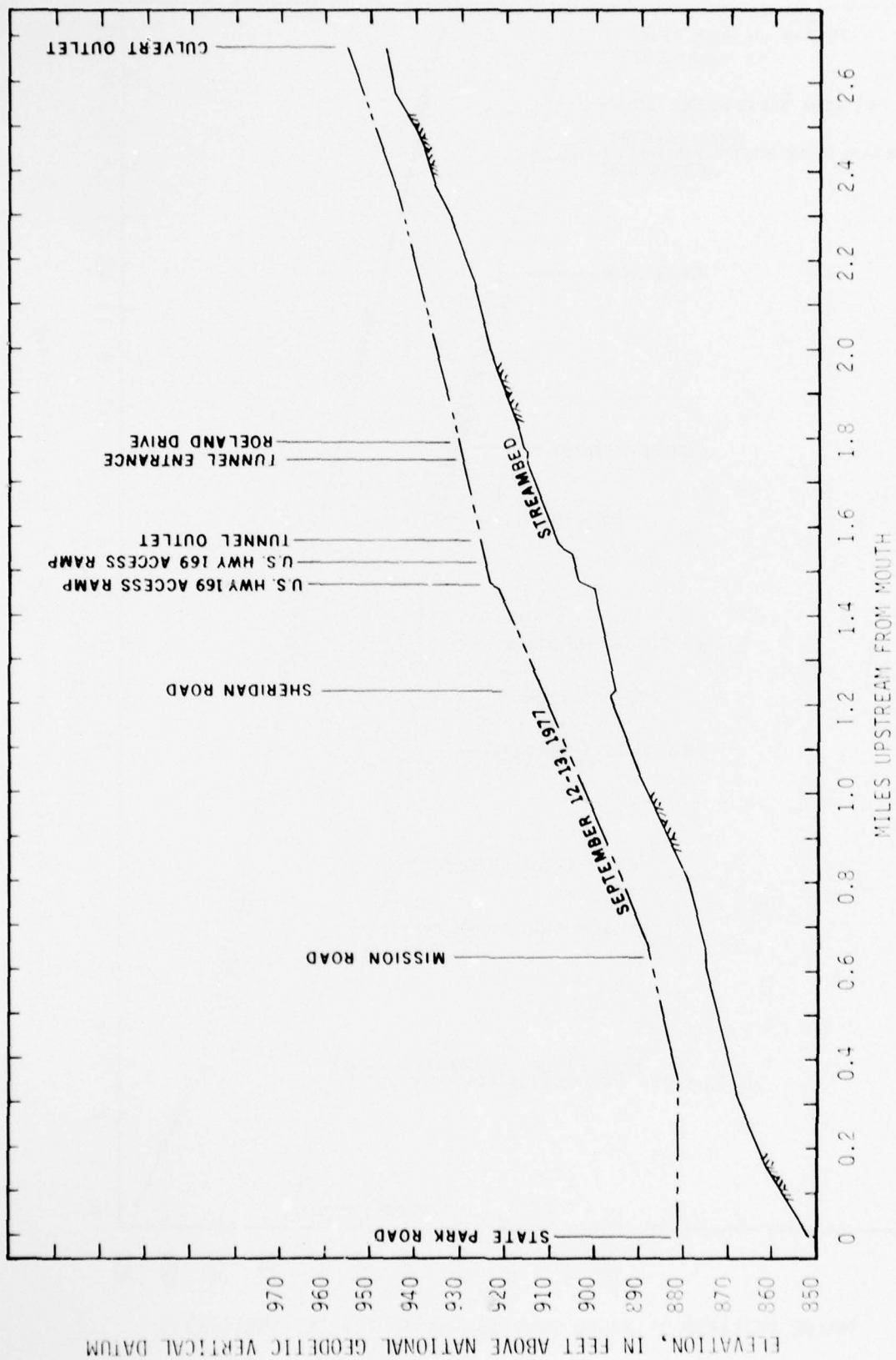


Figure 13.--Profile of water surface of Rock Creek (Kansas), flood of September 12-13, 1977.

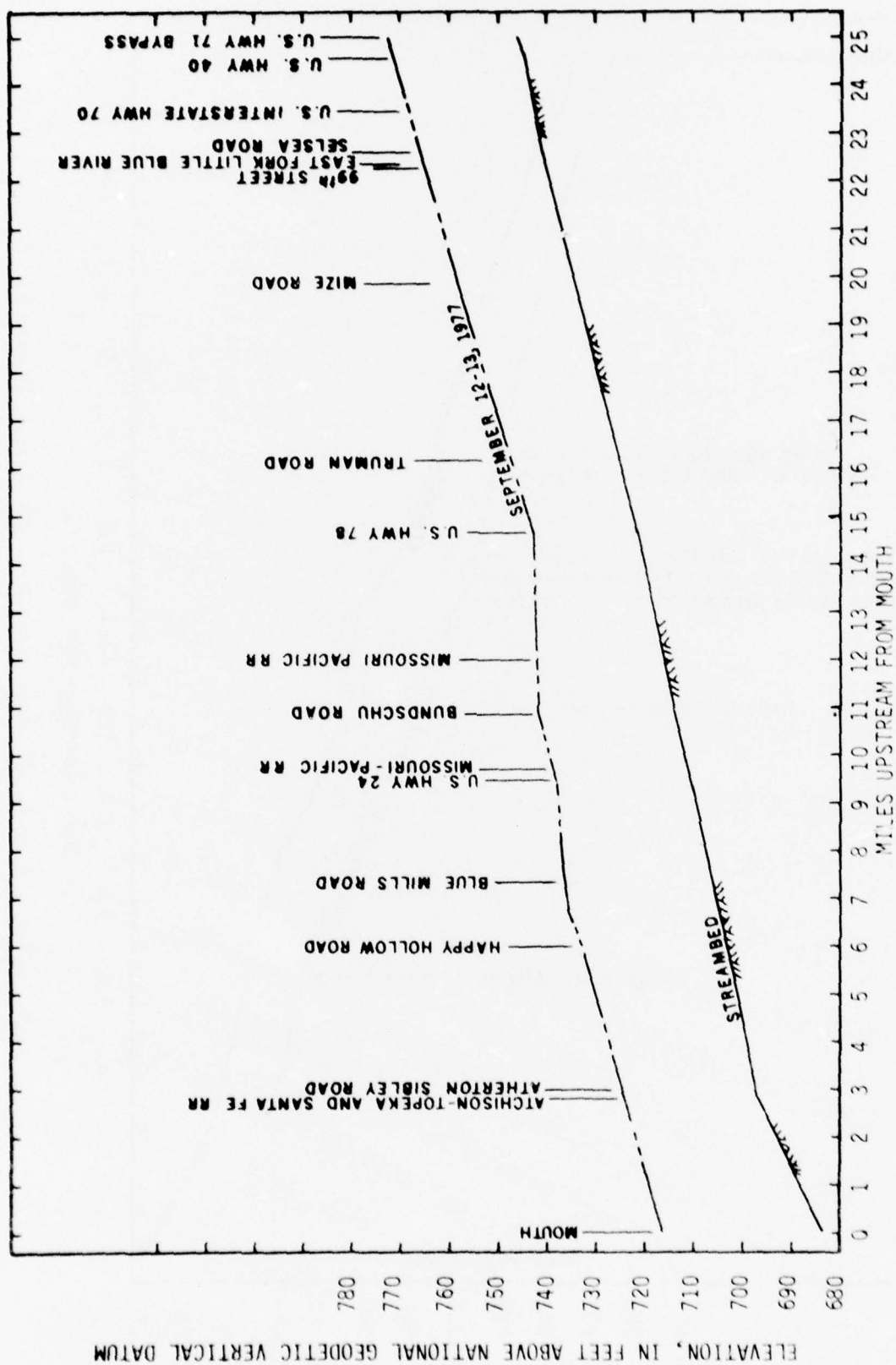


Figure 14.--Profile of water surface of Little Blue River, flood of September 12-13, 1977.

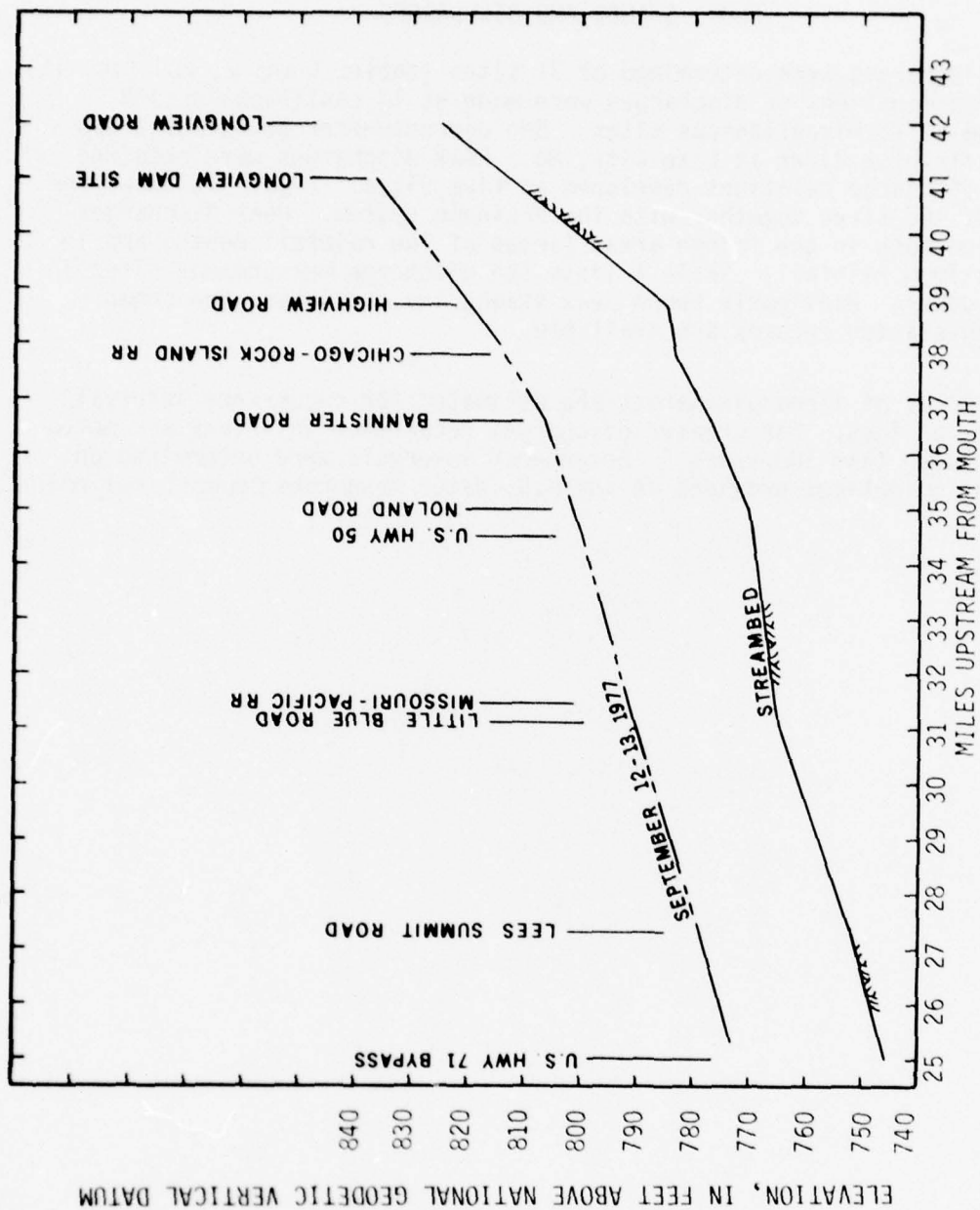


Figure 14.--Profile of water surface of Little Blue River,
flood of September 12-13, 1977--continued.

FLOOD STAGES AND DISCHARGES

Peak discharges were determined at 31 sites (tables 1 and 2, and fig. 15). Indirect determinations of discharges were made at 13 continuous-record stations and at 13 miscellaneous sites. One current-meter measurement was made on Little Blue River at Lake City, Mo. Peak discharges were obtained from stage-discharge relations developed at five sites. Figure 15 shows the locations of the sites together with the drainage system. Peak discharges were measured both in the fringe areas (areas of low rainfall depth) and in areas of maximum rainfall. Table 1 lists the discharge measurement sites in downstream order. Previously known peak stages and discharges are shown where gaging-station records are available.

Frequencies of flood discharges are estimated for recurrence intervals of 100-years or less. For greater discharges recurrence intervals are noted only as "greater than 100-years." Recurrence intervals were determined on the basis of guidelines provided in the U.S. Water Resources Council Bulletin 17 (1976).

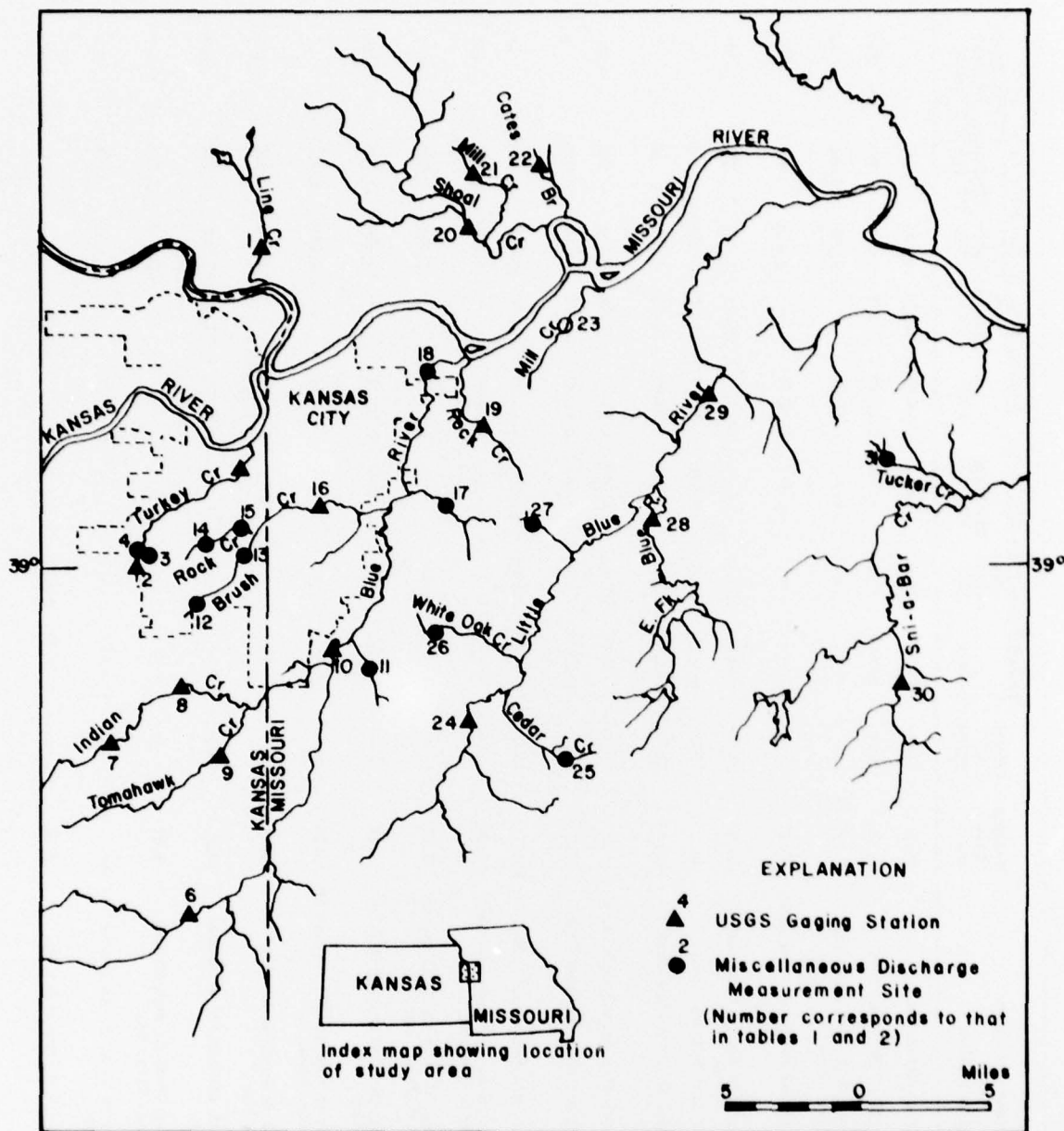


Figure 15.--Flood area and location of flood-determination points.

Table 1.--Summary of peak stages and discharges for floods of September 12-13, 1977

Map No.	Permanent station number	Stream and place of determination	Drainage area (mi ²)	Period of record	Maximum flood previously known			Maximum flood of September 12-13, 1977				
					Date	gage height (ft)	Discharge (ft ³ /s)	Date	gage height (ft)	Discharge (ft ³ /s)	Recurrence interval (years)	
1	06821280	Line Creek at Riverside, Mo.	19.2	1976-	5-18-74	29.0	-----	9-13-77	16.22	4,300	167	5
2	06892800	Turkey Creek at Merriam, Kans.	6.76	1974-	8-26-75	17.11	-----	9-12-77	21.65	5,300	784	100
3	-----	Turkey Creek Trib. at Carter St. at Merriam, Kans.	.82	---	----	---	-----	9-12-77	---	1,200	1,460	50
4	-----	Turkey Creek at 63rd St. at Merriam Kans.	7.84	---	----	---	-----	9-12-77	---	6,490	827	>100
5	06892940	Turkey Creek at Kansas City, Kans.	22.3	1974-	8-26-75	16.31	-----	9-12-77	25.2	11,700	552	>100
6	06893080	Blue River near Stanley, Kans.	46	1970-	6-9-74	16.83	7,500	9-13-77	5.17	214	5	-
7	06893250	Indian Creek near Overland Park, Kans.	14.8	1970-76	6-22-69	21.02	3,300	9-13-77	18.72	1,300	88	3
8	06893300	Indian Creek at Overland Park, Kans.	26.6	1963-	7-15-76	11.62	6,540	9-13-77	15.50	8,820	332	>100
9	06893350	Tomahawk Creek near Overland Park, Kans.	23.9	1970-	6-25-69	19.79	-----	9-13-77	17.74	4,290	179	8
10	06893500	Blue River near Kansas City, Mo.	188	1940-	9-13-61	44.46	41,000	9-13-77	34.74	20,500	109	10
11	-----	Blue River Trib. at Barnister Road near Kansas City, Mo.	3.38	---	----	---	-----	9-13-77	-	4,040	1,195	>100
12	-----	Brush Creek at 75th and Nail Ave. at Prairie Village, Kans.	1.51	---	----	---	-----	9-12-77	-	3,000	1,990	>100
13	-----	Brush Creek at 63rd St. and Mission Hills, Kans.	5.84	---	----	---	-----	9-12-77	-	14,400	2,740	>100
14	-----	Rock Creek at Woodson and Martway St. at Mission, Kans.	1.15	---	----	---	-----	9-12-77	-	1,980	1,720	25
15	-----	Rock Creek at Sheridan Road at Fairway, Kans.	3.04	---	----	---	-----	9-12-77	-	4,900	1,610	>100
16	06893560	Brush Creek at Main St. at Kansas City, Mo.	14.8	1971-	----	---	-----	9-12-77	23.24	17,600	1,243	>100
17	06893570	Round Grove Creek at Baytown Road at Kansas City, Mo.	5.87	---	----	---	-----	---	-	13,200	2,249	>100
18	-----	Blue River at 12th St. at Kansas City, Mo.	264	---	----	---	-----	9-13-77	-	34,900	132	>100
19	06893600	Rock Creek at Independence, Mo.	5.20	1968-	6-19-67	14.22	2,520	9-12-77	16.7	7,760	1,432	>100

Table 1.--Summary of peak stages and discharges for floods of September 12-13, 1977--continued

Map No.	Permanent station number	Stream and place of determination	Drainage area (mi. ²)	Period of record	Maximum flood previously known			Maximum flood of September 12-13, 1977				
					Date	Gage height (ft)	Discharge (ft. ³ /s)	Date	Gage height (ft)	Discharge (ft. ³ /s)	Recurrence interval (years)	
20	06893670	Shoal Creek at Claycomo, Mo.	29.8	1976-	5-18-74	33.18	-----	9-13-77	20.62	8,000	268	20
21	06893680	Mill Creek at 56th St. at Gladstone, Mo.	1.24	---	----	---	-----	9-12-77	-	800	645	15
22	06893710	Cates Branch near Liberty, Mo.	1.95	---	----	---	-----	9-12-77	10.73	2,480	1,272	>100
23	-----	Mill Creek at Courtney Road near Independence, Mo.	1.95	---	----	---	-----	9-12-77	-	2,240	1,149	>100
24	06893793	Little Blue River below Longview Road Damsite at Kansas City, Mo.	50.7	1967-	6-27-69	11.19	-----	9-13-77	21.07	18,100	367	>100
25	-----	Cedar Creek at Lees Summit, Mo.	1.84	---	----	---	-----	9-12-77	-	2,410	1,310	>100
26	-----	White Oak Creek at Raytown Road at Raytown, Mo.	1.78	---	----	---	-----	9-12-77	-	2,290	1,286	>100
27	-----	Little Blue River Trib. at Noland Road at Independence, Mo.	0.83	---	----	---	-----	9-12-77	-	2,330	2,807	>100
28	06893890	East Fork Little Blue River near Blue Springs, Mo.	34.4	1970-	5-18-74	19.19	-----	9-13-77	20.13	5,000	145	10
29	06894000	Little Blue River near Lake City, Mo.	184	1949-	9-14-61	27.94	9,460	9-13-77	23.30	17,500	95.1	>100
30	06894680	Sni-A-Bar Creek near Tarsney, Mo.	29.1	1971-	9-11-77	21.93	4,300	9-13-77	23.30	15,700	540	>100
31	-----	Tucker Creek at Highway FF near Grain Valley, Mo.	1.45	---	----	---	-----	9-12-77	-	1,890	1,303	>100

a At site 500 feet downstream.

Table 2. --Description of discharge measurement sites

Map no.	Permanent station number	Station name	Location
1	06821280-----	Line Creek at Riverside, Mo.	Lat 39°10'32", long 94°36'46", in SW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 4, T. 50 N., R. 33 W., Platte County, just downstream on left bank from bridge of old U.S. Highway 71 at Riverside, 100 ft upstream from Jumping Branch, approximately 1 mi upstream from mouth and 1 mi south of Interstate 29.
2	06892800-----	Turkey Creek at Merriam, Kans.	Lat 39°00'28", long 94°41'56", in SW $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 13, T. 12 S., R. 24 E., Johnson County, on downstream side of bridge on 67th Street, at Merriam, Kans.
3	-----	Turkey Creek tributary at Carter St. at Merriam, Kans.	Lat 39°00'50", long 94°41'48", in NE $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 13, T. 12 S., R. 24 E., Johnson County, at Carter St., and 1,200 ft upstream from mouth.
4	-----	Turkey Creek at 63rd St., at Merriam, Kans.	Lat 39°00'53", long 94°42'03", on line between secs. 12 and 13, T. 12 S., R. 24 E., and at Highway 10 (63rd St.).

Table 2.--Description of discharge measurement sites--continued

Map no.	Permanent station number	Station name	Location
5	06892940-----	Turkey Creek at Kansas City, Kans.	Lat 39°03'31", long 94°37'33", in SE $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 27, T. 11 S., R. 25 E., Wyandotte County, on downstream side of bridge on State Highway 10, at Kansas City, Kans.
6	06893080-----	Blue River near Stanley, Kans.	Lat 38°48'45", long 94°40'31", in SW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 19, T. 14 S., R. 25 E., Johnson County on U.S. Highway 69, 0.5 mi downstream from confluence of Wolf Creek and Coffee Creek, and 3 mi south of Stanley, Kans.
7	06893250-----	Indian Creek near Overland Park, Kans.	Lat 38°54'45", long 94°43'24", in NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 23, T. 13 S., R. 24 E., Johnson County, at right bank, on downstream side of bridge on Morse Road, 2.5 mi southwest of Overland Park, Kans.
8	06893300-----	Indian Creek at Overland Park, Kans.	Lat 38°56'25", long 94°40'10", in NW $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 7, T. 13 S., R. 25 E., Johnson County at bridge on Marty St. in Overland Park, Kans.

Table 2.--Description of discharge measurement sites--continued

Map no.	Permanent station number	Station name	Location
9	06893350-----	Tomahawk Creek near Overland Park, Kans.	Lat 38°54'47", long 94°37'54", in NE¼NE¼ sec. 21, T. 13 S., R. 25 E., Johnson County, at bridge on 119th St., 1.4 mi south of Overland Park, 4.4 mi northeast of Stanley, Kans.
10	06893500-----	Blue River near Kansas City, Mo.	Lat 38°57'26", long 94°33, 41", in SE¼NE¼ sec. 28, T. 48 N., R. 33 W., Jackson County at bridge on old Bannister Road, 0.4 mi downstream from Indian Creek, and at river mile 23.16.
11	-----	Blue River tributary at Bannister Road near Kansas City, Mo.	Lat 38°57'14", long 94°32'17", in SW¼SW¼NW¼ sec. 26, T. 48 N., R. 33 W., at Bannister Road and U.S. Highway 71, 1.3 mi upstream from confluence with Blue River.
12	-----	Brush Creek at 75th St. and Nall Ave. at Prairie Village, Kans.	Lat 39°59'35", long 94°38'55", on line between sec. 20 and 21, T. 12 S., R. 25 E., at 75th St. and Nall Ave.
13	-----	Brush Creek at 63rd St. at Mission Hills, Kans.	Lat 39°00'55", long 94°37'19", in SE¼SE¼SW¼ sec. 10, T. 12 S., R. 25 E., at south edge of Kansas City Country Club at 63rd St. in Mission Hills, Kans.

Table 2. --Description of discharge measurement sites--continued

Map no.	Permanent station number	Station name	Location
14	-----	Rock Creek at Woodson and Martway St. at Mission, Kans.	Lat 39°01'13", long 94°39'14", in SE $\frac{1}{4}$ NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 8, T. 12 S., R. 25 E., between Woodson and Martway St., 1 block north of Mission, Kans., City Hall, and 2.5 mi upstream from con- fluence with Brush Creek.
15	-----	Rock Creek at Sheridan Road at Fairway, Kans.	Lat 39°01'31", long 94°38'04", in NW $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 9, T. 12 S., R. 25 E., at Sheridan Road and at river mile 1.2.
16	06893560	Brush Creek at Main St. at Kansas City, Mo.	Lat 39°02'24", long 94°35'12", in SW $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 29, T. 49 N., R. 33 W., Jackson County at Main St., 4 mi upstream from Blue River.
17	06893570	Round Grove Creek at Raytown Road at Kansas City, Mo.	Lat 39°02'29", long 94°28'59", in SE $\frac{1}{4}$ NE $\frac{1}{4}$ of sec. 30, T. 48 N., R. 32 W., Jackson County, on Raytown Road, 0.5 mi northwest of junction with Rock Creek Road, 1.1 mi southeast of junction with Interstate Highway 435, and 1.8 mi upstream from confluence with Blue River.

Table 2.--Description of discharge measurement sites--continued

Map no.	Permanent station number	Station name	Location
18	-----	Blue River at 12th St. at Kansas City, Mo.	Lat 39°05'48", long 94°29'24", in NW¼NE¼SW¼ sec. 6, T. 49 N., R. 32 W., Jackson County, at 12th St. and Interstate Highway 435 exit ramp, 0.2 mi downstream from Truman Road, and at river mile 4.3.
19	06893600-----	Rock Creek at Independence, Mo	Lat 39°04'37", long 94°27'03", in NW¼SW¼SE¼ sec. 9, T. 49 N., R. 23 W., at Northern Blvd. in Independence, one-fourth mi south of 23rd St., and at river mile 4.0.
20	06893670-----	Shoal Creek at Claycomo, Mo.	Lat 39°12'27", long 94°28'45", in NE¼NW¼NE¼ sec. 27, T. 51 N., R. 32 W., Clay County, at U.S. Highway 69, 2.5 mi upstream from confluence with Little Shoal Creek, 10 mi upstream from con- fluence with Missouri River.
21	06893680-----	Mill Creek at 56th St. at Gladstone, Mo.	Lat 39°11'43", long 94°32'54", on sec. line between secs. 30 and 31, along Antioch Road, 1.96 mi upstream from Rock Creek on corporate boundary line between Gladstone and Kansas City, and at river mile 6.17.

Table 2.--Description of discharge measurement sites--continued

Map no.	Permanent station number	Station name	Location
22	0689710-----	Cates Branch near Liberty, Mo.	Lat 39°13'16", long 94°24'53", in NW¼NW¼ sec. 20, T. 51 N., R. 32 W., Clay County, on Sherril Drive 0.2 mi west of U.S. Highway 71 bypass, 0.7 mi upstream from mouth, 1.2 mi south of junction of Highways 33 and 71 bypass at Liberty, Mo.
23	-----	Mill Creek at Courtney Road near Independence, Mo.	Lat 39°07'56", long 94°24'16", in NW¼SE¼SE¼ sec. 23, T. 50 N., R. 32 W., Jackson County, about 0.2 mi downstream from Kentucky Road, at private drive, and 1.3 mi upstream from U.S. Highway 71.
24	06893793-----	Little Blue River below Longview Road Dam site at Kansas City, Mo.	Lat 38°55'52", long 94°28'12", in NW¼SE¼SE¼ sec. 32, T. 48 N., R. 32 W., Jackson County, 700 ft downstream from Longview Dam site, 1 mi downstream from Longview Road, and 2 mi upstream from Cedar Creek.
25	-----	Cedar Creek at Lees Summit, Mo.	Lat 38°54'10", long 94°24'12", in NW¼NW¼SE¼ sec. 12, T. 47 N., R. 31 W., Jackson County, 0.1 mi upstream from tributary, and at Chicago-Rock Island and Pacific Railroad stream crossing.

Table 2.--Description of discharge measurement sites--continued

Map no.	Permanent station number	Station name	Location
26	-----	White Oak Creek at Raytown Road at Raytown, Mo.	Lat 38°58'15", long 94°27'54", in SW¼NE¼SE¼ sec. 20, T. 48 N., R. 32 W., Jackson County, 1.3 mi north of Bannister Road, 2.7 mi upstream from confluence with Little Blue River.
27	-----	Little Blue River tributary at Noland Road at Independence, Mo.	Lat 39°01'42", long 94°24'50", in NW¼NW¼NE¼ sec. 35, T. 49 N., R. 32 W., Jackson County, 0.5 mi south of Alternate Highway 40 and 0.3 mi north of Missouri Pacific Railroad on Noland Road, and 1.7 mi above confluence with Little Blue River.
28	06893890-----	East Fork Little Blue River near Blue Springs, Mo.	Lat 39°01'32", long 94°20'37", in NE¼NE¼NW¼ sec. 33, T. 49 N., R. 31 W., Jackson County, on U.S. Highway 40, 2.6 mi west of Blue Springs, and 1.5 mi upstream from mouth.
29	06894000-----	Little Blue River near Lake City, Mo.	Lat 39°06'02", long 94°18'01", in SW¼SE¼ sec. 35, T. 50 N., R. 31 W., Jackson County, on dual State Highway 78, 3 mi southwest of Lake City, and 10.5 mi upstream from mouth.

Table 2.--Description of discharge measurement sites--continued

Map no.	Permanent station number	Station name	Location
30	06894680-----	Sni-A-Bar Creek near Tarsney, Mo.	Lat 38°56'28", long 94°10'05", in SW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 30, T. 48 N., R. 29 W., Jackson County, on Colburn Road, 2.3 mi upstream from West Fork, 2.7 mi east of Tarsney and 5 mi southeast of Grain Valley.
31	-----	Tucker Creek at Highway FF near Grain Valley, Mo.	Lat 39°03'52", long 94°07'24", on divide between secs. 12 and 13, T. 49 N., R. 30 W., Jackson County, on Highway FF, 1.2 mi east of intersection with Highway BB, and 3.5 mi north of Grain Valley.

Comparison with Maximum Known Discharges

Peak discharges of the September 1977 flood, together with peak discharges of the July 1951 flood in Missouri and Kansas (U.S. Geol. Survey, 1952, p. 199), are plotted against their respective drainage areas in figure 16 for comparison with previous maximum discharges known in the United States. A curve developed by Matthai (1965) on basis of maximum floods known in the United States defines the approximate upper limit of known floods in 1965 (fig. 16). Peak discharges encountered in the September 1977 flood do not approach the maximum flood experience defined by Matthai. Curve values are more than double the highest peak flows of September 12-13, 1977.

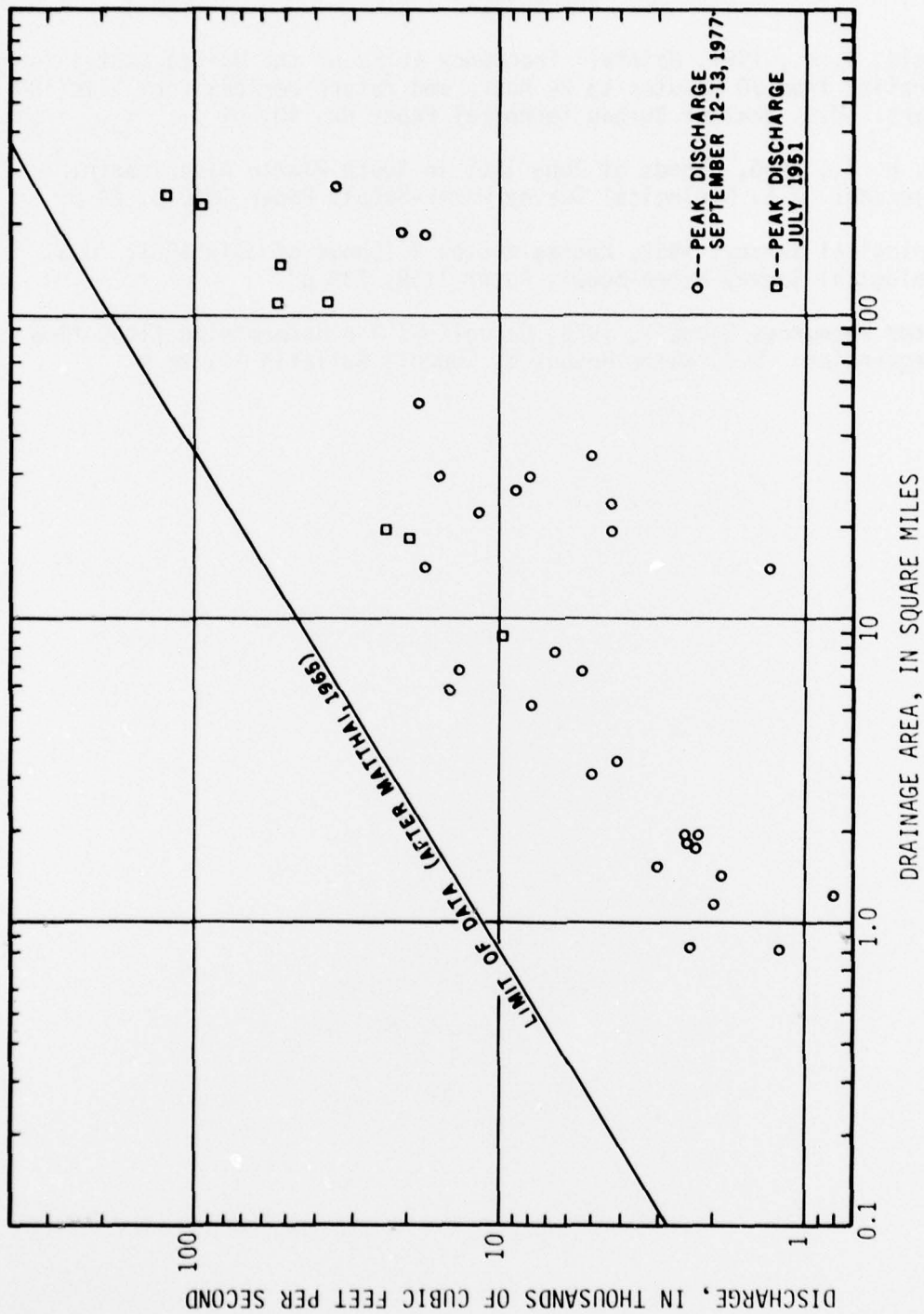


Figure 16.--Comparison of September 12-13, 1977, peak discharges to upper limit of known floods in the United States.

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